Exposure Calculation Report

Logic Energy Ltd
Wind Speed Logger, Model: WINDCRANE

In accordance with EN 50665

Prepared for: Logic Energy Ltd
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EXECUTIVE SUMMARY
The calculation of exposure for this product was found to be compliant at a minimum distance of 50 cm with EN 50665: 2017 assuming continuous exposure of 6 minutes or more. If alternative antennas are used with greater gains, the distance must be recalculated.

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Contents

1 Report Summary 2

1.1 Report Modification Record 2
1.2 Introduction 2
1.3 Brief Summary of Results 3
1.4 Product Information 4

2 Assessment Details 6

2.1 Assessment Method 6
2.2 Individual Antenna Port Exposure Results 7
2.3 Far Field Region Boundary Results 8
2.4 Uncertainty 8

Annex A Regional Requirements **A.2**

1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Issue	Description of Change	Date of Issue
1	First Issue	17 November 2022

Table 1

1.2 Introduction

Applicant	Logic Energy Ltd
Manufacturer	Logic Energy Ltd
Model Number(s)	WINDCRANE
Hardware Version(s)	1.12
Software Version(s)	w1.12
Specification/Issue/Date	• EN 50665:2017 Generic standard for assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz)
Order Number Date	188542 Rev: 1 05-September-2022
Related Document(s)	• EN 62311:2008 Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz to 300 GHz) • Directive 2013/35/EU on minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields). • European Council Recommendation 1999/519/EC of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz), Official Journal, L199, of 1999-7-30, p.59-70

1.3 Brief Summary of Results

The wireless device described within this report was compliant with the restrictions related to human exposure to electromagnetic fields for both general public and worker/occupational exposures.

The calculations shown in this report were made in accordance with the procedures specified in the applied test specification(s).

1.3.1 Configuration - Single Transmitter

Regional Requirement	RAT	Calculated RF exposure level at minimum compliance boundary of 0.5 m							
		S Power Density (W/m^2)		E Field (V/m)		H Field (A/m)		B Field (µT)	
		Result	Limit	Result	Limit	Result	Limit	Result	Limit
EN	E-GSM-900	0.01	N/A	1.55	88.99	0.0041	N/A	0.0052	0.2966
EN	DCS-1800	0.00	N/A	1.10	124.06	0.0029	N/A	0.0037	0.4135
EN	LTE Band 1	0.00	N/A	0.55	131.45	0.0015	N/A	0.0018	0.4382
EN	LTE Band 3	0.00	N/A	0.55	124.06	0.0015	N/A	0.0018	0.4135
EN	LTE Band 8	0.00	N/A	0.55	88.99	0.0015	N/A	0.0018	0.2966
EN	LTE Band 20	0.00	N/A	0.55	86.53	0.0015	N/A	0.0018	0.2884
EN	LTE Band 28	0.00	N/A	0.55	79.54	0.0015	N/A	0.0018	0.2651

Table 2 – Worker/Occupational Exposure Results

The calculations show that the EUT complies with the worker/occupational exposure levels described in in the listed specifications in Annex A at the point of investigation, a minimum of 0.5 m.

Regional Requirement	RAT	Calculated RF exposure level at minimum compliance boundary of 0.5 m							
		S Power Density (W/m^2)		E Field (V/m)		H Field (A/m)		B Field (µT)	
		Result	Limit	Result	Limit	Result	Limit	Result	Limit
EN	E-GSM-900	0.01	4.40	1.55	40.79	0.0041	0.1098	0.0052	0.1365
EN	DCS-1800	0.00	8.55	1.10	56.86	0.0029	0.1530	0.0037	0.1902
EN	LTE Band 1	0.00	9.60	0.55	60.25	0.0015	0.1621	0.0018	0.2016
EN	LTE Band 3	0.00	8.55	0.55	56.86	0.0015	0.1530	0.0018	0.1902
EN	LTE Band 8	0.00	4.40	0.55	40.79	0.0015	0.1098	0.0018	0.1365
EN	LTE Band 20	0.00	4.16	0.55	39.66	0.0015	0.1067	0.0018	0.1327
EN	LTE Band 28	0.00	3.52	0.55	36.46	0.0015	0.0981	0.0018	0.1220

Table 3 – General Public Exposure Results

The calculations show that the EUT complies with the general public exposure levels described in in the listed specifications in Annex A at the point of investigation, a minimum of 0.5 m.

1.4 Product Information

1.4.1 Technical Description

Wind speed logger unit with cellular telemetry

1.4.2 Transmitter Description

The following radio access technologies and frequency bands are supported by the equipment under test.

Radio Access Technology	Frequency Band (MHz)	Minimum Frequency (MHz)	Output Power (dBm)	Duty Cycle (%)
E-GSM-900	880.0-915.0	880.0	33.0	1
DCS-1800	1710.2-1784.8	1710.2	30.0	1
LTE Band 1	1920.0-1980.0	1920.0	24.0	1
LTE Band 3	1710.0-1785.0	1710.0	24.0	1
LTE Band 8	880.0-915.0	880.0	24.0	1
LTE Band 20	832.0-847.0	832.0	24.0	1
LTE Band 28	703.0-748.0	703.0	24.0	1

Table 4 – Transmitter Description

Notes:

- Duty cycle set at 1% as the product only transmits a short data burst every 10 minutes
- Transmitter power includes upper bounds of uncertainty therefore maximum values are used in accordance with Section 2.4.

1.4.3 Antenna Description

The following antennas are supported by the equipment under test.

Radio Access Technology	Antenna Model	Gain (dBi)	Antenna length (cm)	Minimum Separation Distance (cm)
E-GSM-900	Delgado S LTE	0	7.2	50
DCS-1800	Delgado S LTE	0	7.2	50
LTE Band 1	Delgado S LTE	0	7.2	50
LTE Band 3	Delgado S LTE	0	7.2	50
LTE Band 8	Delgado S LTE	0	7.2	50
LTE Band 20	Delgado S LTE	0	7.2	50
LTE Band 28	Delgado S LTE	0	7.2	50

Table 5 – Antenna description

In the case of more than one type of antenna being supported by the equipment, the calculation is based on the maximum of the antenna gains. If other antennas can be used that have greater gains, the minimum separation distances will need to be recalculated.

Note: Antenna gain includes upper bounds of uncertainty therefore maximum values are used in accordance with Section 2.4.

2 Assessment Details

2.1 Assessment Method

The assessment method is by calculation of the power density S, electric field strength E, magnetic field strength H or magnetic flux density B.

The calculation uses the spherical model applicable under far field conditions and also radiating near field conditions where applicable (see Section 2.3).

$$S = E \times H = \frac{E^2}{\eta} = H^2 \times \eta = \frac{P \times G_i}{4 \times \pi \times r^2}$$

Where:
η - Impedance of free space (377 ohm in far field)
P – Average transmitter power W (P_{av} = P_{max} x Duty Cycle)
G_i – Antenna gain ratio relative to isotropic
r – Separation distance m

The magnetic flux density is related to the magnetic field strength by a constant:

$$B = \mu_o \times H$$

Where:
μ_o – Permeability of free space 4 x π E-7 H/m

This assessment assumes that exposure is continuous for 6 minutes or more in accordance with the averaging time required by the exposure standards at the stated minimum compliance boundary separation distance. Exposures of less than 6 minutes at other separation distances are not addressed by this report.

This assessment method of RF exposure is applicable to separation distances of 20 cm or more beyond the reactive near field boundary. Separation distances of less than 20 cm require a Specific Absorption Rate (SAR) assessment.

The reactive near field boundary and far field region boundary depend on the frequency and wavelength and also on the antenna dimension. The boundaries of the field regions are calculated in Section 2.3 to demonstrate the validity of using the spherical model.

The result is compared to the limits in Annex A to determine compliance or to calculate the required compliance distance. The calculation is based on the lowest frequency in each band as the most onerous requirement as the limits increase with frequency for frequencies above 10-50 MHz (dependent on region).

2.2 Individual Antenna Port Exposure Results

2.2.1 Calculation of Exposure at Specified Separation Distance

The frequencies shown in the tables below have been chosen based on the lowest possible frequency that the EUT can transmit. A full list of the regional requirements is shown in Annex A.

Regional Requirement	RAT	Frequency (MHz)	RF Exposure Level at minimum compliance boundary of 0.5 m							
			S Power Density (W/m^2)		E Field (V/m)		H Field (A/m)		B Field (µT)	
			Result	Limit	Result	Limit	Result	Limit	Result	Limit
EN	E-GSM-900	880.0	0.01	N/A	1.55	88.99	0.0041	N/A	0.0052	0.2966
EN	DCS-1800	1710.2	0.00	N/A	1.10	124.06	0.0029	N/A	0.0037	0.4135
EN	LTE Band 1	1920.0	0.00	N/A	0.55	131.45	0.0015	N/A	0.0018	0.4382
EN	LTE Band 3	1710.0	0.00	N/A	0.55	124.06	0.0015	N/A	0.0018	0.4135
EN	LTE Band 8	880.0	0.00	N/A	0.55	88.99	0.0015	N/A	0.0018	0.2966
EN	LTE Band 20	832.0	0.00	N/A	0.55	86.53	0.0015	N/A	0.0018	0.2884
EN	LTE Band 28	703.0	0.00	N/A	0.55	79.54	0.0015	N/A	0.0018	0.2651

Table 6 – Worker/Occupational Individual Transmitter Result

The calculations show that the EUT complies with the worker/occupational exposure levels described in in the listed specifications in Annex A at the point of investigation, a minimum distance of 0.5 m.

Regional Requirement	RAT	Frequency (MHz)	RF Exposure Level at minimum compliance boundary of 0.5 m							
			S Power Density (W/m^2)		E Field (V/m)		H Field (A/m)		B Field (µT)	
			Result	Limit	Result	Limit	Result	Limit	Result	Limit
EN	E-GSM-900	880.0	0.01	4.40	1.55	40.79	0.0041	0.1098	0.0052	0.1365
EN	DCS-1800	1710.2	0.00	8.55	1.10	56.86	0.0029	0.1530	0.0037	0.1902
EN	LTE Band 1	1920.0	0.00	9.60	0.55	60.25	0.0015	0.1621	0.0018	0.2016
EN	LTE Band 3	1710.0	0.00	8.55	0.55	56.86	0.0015	0.1530	0.0018	0.1902
EN	LTE Band 8	880.0	0.00	4.40	0.55	40.79	0.0015	0.1098	0.0018	0.1365
EN	LTE Band 20	832.0	0.00	4.16	0.55	39.66	0.0015	0.1067	0.0018	0.1327
EN	LTE Band 28	703.0	0.00	3.52	0.55	36.46	0.0015	0.0981	0.0018	0.1220

Table 7 – General Public Individual Transmitter Result

The calculations show that the EUT complies with the general public exposure levels described in in the listed specifications in Annex A at the point of investigation, a minimum distance of 0.5m.

2.3 Far Field Region Boundary Results

The far field region boundary calculation result is shown in Table 8:

Near Field / Far Field Boundary (Ref: EN 62311:2008 / EN 62232 Annex A)			
RAT Name	Frequency MHz	Reactive Near Field Boundary (Wave Impedance Dependent)	Far Field Boundary (Antennas on axis)
		λ/4 (m)	$2D^2/\lambda$ (m)
E-GSM-900	880.0	0.0852	0.0852
DCS-1800	1710.2	0.0439	0.0591
LTE Band 1	1920.0	0.0391	0.0664
LTE Band 3	1710.0	0.0439	0.0591
LTE Band 8	880.0	0.0852	0.0852
LTE Band 20	832.0	0.0901	0.0901
LTE Band 28	703.0	0.1067	0.1067

Table 8 – Far Field Boundary (EN)

The table below shows the maximum calculated near field / far field region boundaries.

The compliance boundary of 0.5 is in the far field region and therefore, the approach described in section 2.1 is valid.

Field Region	Reactive Near Field Region	Radiating Near Field Region	Far Field Region
Maximum Boundary	<0.1067 m	N/A	> 0.1067 m
Validity of Regions	Spherical model potential under-estimate: SAR / test assessment required	Spherical model over-estimate and conservative	Spherical model valid
Compliance Boundary Location	N/A	N/A	0.5 m

Table 9 – Assessment Method Validity

2.4 Uncertainty

The basic computation formulas presented in section 2.1 are conservative formulas for the estimation of RF field strength or power density.

No uncertainty estimations are required when using these formulas but there is clear guidance on where and when these formulas are applicable. For the estimate of S, E or H to be conservative, the transmitter power P and antenna gain G_i values shall be the upper bounds of uncertainty therefore maximum values are used.

The spherical formula is valid under far field conditions which are established in section 2.3.

ANNEX A

REGIONAL REQUIREMENTS

Frequency Range (MHz)	Power Density (W/m^2)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Magnetic Flux Density (µT)
0.1 - 1	-	610	N/A	2/f
1 - 10	-	610/f	N/A	2/f
10 - 400		61	N/A	0.2
400 - 2000		3*f^0.5	N/A	1E-2*f^0.5
2000 - 6000		140	N/A	0.45
6000 - 300000	50	140	N/A	0.45

Table A.1 – EN: Action levels in Directive 2013/35/EU Annex III Table B1 Worker/Occupational Limits

Frequency Range (MHz)	Power Density (W/m^2)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Magnetic Flux Density (µT)
0.003 - 0.15	-	87	5	6.25
0.15 - 1	-	87	0.73/f	0.92/f
1 - 10	-	87/f^0.5	0.73/f	0.92/f
10 - 400	2	28	0.073	0.092
400 - 2000	f/200	1.375*f^0.5	0.0037*f^0.5	0.0046*f^0.5
2000 - 300000	10	61	0.16	0.2

Table A.2 – EN: Council Recommendation 1999/519/EC Annex II Table 1 General Public Limits